DOCUMENT RESUME

ED 209 807 EC 140 321

AUTHOR Tomlinson-Keasey, C.
TITLE Does Listening to Language Promote Hemispheric Specialization.
PUB DATE Apr 81
NOTE 22p.; Paper presented at the Meeting of the Society for Research in Child Development (Boston, MA, April 2-5, 1981).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Aural Learning; *Deafness; Elementary Education; *Lateral Dominance; Listening Skills

ABSTRACT

Cerebral laterality was examined for third, fourth, and fifth grade deaf (N=30) and hearing (N=30) Ss. The experimental task involved the processing of word and picture stimuli presented singly to the right and left visual hemifields. The analyses indicated that deaf children were faster than the hearing children in overall processing efficiency, and that they performed differently in regard to hemispheric lateralization. The deaf children processed the stimuli more efficiently in the right hemisphere, while the hearing children demonstrated a left hemisphere proficiency. This finding is discussed in terms of the hypothesis that cerebral lateralization is influenced by auditory processing. (Author)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED209807

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

Does Listening to Language Promote Hemispheric Specialization

C. Tomlinson-Keasey

University of California-Riverside

Paper presented at SRCD April 1981

Boston, Massachusetts

C. Tomlinson-Keasey
Psychology Department
UC-Riverside
Riverside, CA 92521
(714) 787-4383

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

C. Tomlinson-Keasey

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

EC 140 321

The Effect of Auditory Input on Cerebral Laterality

The focus of many hemispheric specialization studies has been on language or language related processing. The consistent relationships found between hemispheric specialization and language functioning have prompted investigators to ask if hearing language actually serves as a stimulus for specialization of the cerebral hemispheres. Leiberman (1974a, 1974b), for example, has hypothesized that the language hemisphere becomes specialized for hearing individuals as the result of processing the grammatical codings involved in speech perception. Evidence supporting this view has been provided by Geschwind and Levitsky (1968) and Witelson and Pallie (1973). A contrasting point of view is taken by Kinsbourne & Hiscock (1977) who argue that lateralization of function is present at birth and does not seem to go through a developmental process (Hiscock & Kinsbourne, 1977). At least one longitudinal study of children followed from Kindergarten to fourth grade indicates that there is minimal change in hemispheric specialization as indicated by dichotic listening assessments during this age period (Bakker, 1979).

Studying the hemispheric specialization of congenitally deaf individuals should help resolve this conflict since these subjects have had no auditory experience. If their specialization differs markedly from the hemispheric specialization of hearing individuals, auditory input may be seen as one important stimulus for cerebral specialization. If the hemispheric specialization of deaf subjects is very similar to hearing subjects, the importance of audition, per se, can be minimized.

Clinical studies of deaf adults who became aphasic and exhibited a communication impairment have been one source of data on the lateralization of language in the hearing impaired. Sarno, Swisher and Sarno (1969) provide

evidence that congenitally deaf persons show losses of manual communication skills following left hemisphere lesions. From their findings, Sarno et al. (1969) suggest that aphasia in the deaf is analogous to that of the hearing, with the only difference being in the method of communication that is impaired. Kimura (1976) also showed an association between manual communication disorders and left hemispheric damage in the deaf. This finding was based on seven cases of aphasia in deaf adults cited in the literature dating back to 1896. However, Kimura (1976) has hypothesized that the left hemisphere's specialized functions may be related primarily to the control of complex motor behavior. Thus the disturbances of sign language and of speech may be interpreted as disorders of certain motor functions in which the linguistic impairment is secondary (Kimura, Battison & Lubert, 1976).

Although the findings are interesting, one can't generalize about hearing impaired populations from these clinical studies. Not only are the reports of aphasia in the deaf extremely rare, but there is also room for considerable doubt that the few deaf subjects studied constitute representative sample. Furthermore, these data do not really address the effect of audition on lateralization because motor control was usually a confounding variable. Finally, few of the clinical studies attended to variables like degree of hearing loss and age of onset, which could have confounded the observations.

Another source of information on the laterality of the hearing impaired is the psychological research conducted on neurologically normal deaf subjects. McKeever, Hoemann, Florian, and VanDeventer (1976) utilized a visual processing task for English words and American Sign Languate to examine cerebral laterality in the congenitally deaf. All of their college aged subjects

had learned American Sign Language (ASL) from age five or earlier. Even with this relatively early experience with signing McKeever et al. (1976) found minimal cerebral asymetries for processing linguistic and nonlinguistic material. Hence they concluded that auditory experience could be a salient factor in the development of cerebral functional asymmetries. Certainly their data suggest that the cerebral organization of communication functions are not comparable in deaf and hearing individuals. Manning, Gobe, Markman and LaBreche (1977) also found an atypical pattern of hemispheric specialization in their tachistoscopic study of deaf adolescents. They suggest that the congenitally deaf use bilateral representation more than hearing subjects; but they acknowledge some methodological difficulties that might have obscured a LVF dominance for American Sign Language. Phippard (1977) compared the hemispheric specialization of deaf subjects (aged 11-19) who used either total communication or oral communication. She found that the deaf subjects whose communication system was exclusively oral showed a left visual field (LVF) advantage for the perception of both verbal and nonverbal stimuli, while no hemifield differences were observed for those whose communication was primarily manual. Her study and the Manning et al. study indicate that a variety of variables probably influence hemispheric specialization.

Scholes and Fischler (1979) devised a task that required adolescents to use both analytical and linguistic processes. Although hearing subjects evidenced the expected RVF superiority, deaf subjects did not. Here, again, the loss of audition could have affected hemispheric specialization. Poizner, Battison and Lane (1979) interjected another view after they examined hemispheric specialization for words, static signs from American Sign Language, and moving signs. Their findings, that words are processed more efficiently in the left hemisphere, that static signs are processed more efficiently in

the right hemisphere, and that moving signs show no functional specialization prompted them to conclude that auditory experience is not a necessary condition for left hemispheric specialization for words.

Of interest in this brief review of recent research on the hemispheric specialization of the deaf is the age of the subjects used. All of the studies reported have concentrated on adolescents or adults. Yet it is possible that the patterns of specialization seen in deaf adolescents are a reflection of their developmental history with signs and words. Congenitally deaf subjects depend heavily on visual processing to obtain information from the environment and "homemade" signs are often the only means of communication until the child begins school. The analytical and reading training that begins in school may gradually occasion more left hemispheric specialization. If this is the case, one might expect signs and words to be processed differently in adolescents (McKeever et al., 1976). However, younger deaf children might rely more on spatial processing, and hence evidence a clearer LVF specialization than the deaf adolescents and adults already studied. Deaf children may also take much longer to develop the kind of analytical processing skills investigated by Scholes and Fischler (1979) simply because they must rely on visual cues that are less efficient at evoking analytical skills. The deaf might, then, follow very different phases in the development of hemispheric specialization, and evidence from a younger age group should help clarify the role of audition in the development of hemispheric specialization.

In the present study, designed to examine the effect of auditory input on cerebral lateralization in elementary school children, the central hypothesis was that congenital hearing loss would directly influence the lateral organization of the brain, prompting a reliance on visual spatial processing

and the right hemisphere. A secondary concern was the comparison of the processing efficiency of the verbal and nonverbal stimuli. It was predicted (a) that the deaf subjects would show a general LVF preference for processing the stimulus items in contrast to the hearing subjects who would demonstrate a general RVF preference, (b) that the deaf would process all stimuli equally well in the LVF while the hearing would show differing asymmetries for the verbal and nonverbal items, and (c) that young deaf children would be more efficient in overall processing ability because they would have a tendency to treat all stimuli in a visual manner, rather than processing the verbal and nonverbal items differently.

Method

Subjects

A total of 30 deaf subjects and 30 hearing subjects (15 males and 15 females in each of the groups) were examined in this study. The deaf subjects were all congenitally deaf and had a hearing loss of at least 85 dB in the better ear. The deaf subjects (mean age 10 years, 9 months) were upper elementary level students (approximately 3rd-5th grades) from a middle-class suburban area in the Midwest. The hearing subjects (mean age 8 years, 8 months) were 3rd and 4th grade students in the same area. All of the hearing and deaf subjects were right handed and had normal vision. None of the deaf children had multiple handicaps and all had tested at near normal levels (IQ>90) on the performance sections of the WISC.

Procedures

The subjects were tested individually. Each sat at a rear projection booth with her/his forehead in a headrest 61.5 cm from the screen. The instructions for the deaf subjects were presented in signed English and were accompanied by slides illustrating the steps in the experiment. Briefly, the instructions to the subjects were as follows: Place your forehead on

the headrest; and look directly at the fixation dot on the screen. When the experimenter flashes the "ready" light on the screen, be sure to focus on the dot. A slide will appear with either a picture or a word on it. There will then be a brief (2 sec) blank period. After the blank period a second slide with either a picture or a word on it will be shown. After you have seen the second slide, push either the "yes" or "no" button to indicate whether the first and second slide are alike.

The experimenter then "talked" (with signs) each subject through ten practice stimulus pairs which were presented at slow speed. None of the subjects had any difficulty understanding the requirements of the task. After the practice trials, the stimuli were always presented for 100 msec. The instructions and procedures for the hearing subjects were the same with two exeptions: a verbal "ready" was used instead of a flashing light, and sign language was not utilized.

Stimuli

The stimulus pairs consisted of either words or pictures presented singly to the visual hemifields. The word stimuli were 18-point Gothic style lower-case letters and were presented only in a horizontal position beginning two degrees to either the left or right side of the fixation point. The IBM Gothic style is a relatively easy typeface to identify and hence is likely to show a right field superiority and to elicit fewer errors than a type that is a more difficult to discriminate (Bryden & Allard, 1976). The picture stimuli when projected were approximately the same width and height as the words--1.3 cm wide by a .8 cm high. Stimuli were projected in a 10.2 X 15.2 cm field with 64 foot candle illumination.

Only the trials in which both stimuli were projected to the same visual hemifield were analyzed, although it was necessary to randomly intersperse

them with an equal number of trials in which the stimulus slides in a pair were presented to both the LVF and RVF. This procedure was used so subjects would not be able to anticipate where the second stimulus would appear.

The stimuli consisted of word and picture pairs. Each content item was used only once to eliminate any practice effect. All of the word stimuli were three and four letter words. An equal number of high image words (Paivio, Yuille, & Madigan, 1968) and low image words (articles, conjunctions and prepositions) were presented. The pictures consisted of an equal number of concrete and abstract pairs. The concrete pictures represented high image words on Paivio's list; the abstract pictures (see figure 1) were drawn purely as nondescript visuals which were very difficult to describe with a verbal label.

Insert Figure 1 about here

Half of the stimulus pairs were matched items, half were not. The decision to use matched and unmatched stimuli was based on the analyses of variables influencing hemispheric functioning provided by Bradshaw, Gates, and Patterson (1976) and Tomlinson-Keasey & Kelly (1979). The unmatched words and pictures differed on several dimensions (i.e. words near and like, and pictures of a bell and frog). These gross differences made a "holistic" response possible. Because the unmatched stimuli were so different, when the stimuli were similar, subjects knew that they matched without inspecting every detail.

Both the content and the order of the 40 trials were determined randomly. All subjects received the same order of trials for the stimulus pairs. The stimuli were projected through a Kodak Carousel 750 projector with a tachistoscopic shutter mounted on the slide projector lens. A specially

constructed sequential timer advanced the slide projector via a photo-transistor and controlled the duration of the stimulus items. The subjects' response buttons were connected directly to the timer.

Results

Table 1 provides the mean reaction times (in msec) of both groups for stimuli projected to the LVF and RVF.

Insert Table 1 about here

A 2 X 2 X 4 X 2 (groups X visual hemifields X modes X match-unmatch) analysis of variance with repeated measures on all variables except groups were conducted. A significant two-factor interaction involving the groups X hemifield variables indicated that the deaf and hearing subjects performed differently with the stimuli in the left and right visual hemifields $F(1,58) = 33.99$, $p < .01$. A second interaction also occurred between the modes X hemifields $F(3,174) = 4.04$, $p < .01$. These interactions are graphed in Figure 2.

Insert Figure 2 about here

Due to these interactions, separate analyses were conducted on the data of the two groups. As predicted the deaf subjects reacted significantly faster to the stimuli in the LVF $F(1,29) = 21.07$, $p < .01$; while the hearing subjects reacted faster to the stimuli in the RVF $F(1,29) = 14.35$, $p < .01$. Figure 1 shows that this general results does not hold when the deaf are processing words that have a very low image value. When directed to the LVF these short articles, prepositions, and conjunctions required the longest processing time; however, they were processed relatively efficiently by the RVF. The

significant difference between the two hemifields of hearing subjects was due largely to the very different processing of the articles, prepositions, and and conjunctions in the RVF and LVF.

The second prediction, that the hearing subjects would show different asymmetry for pictures and words, was not confirmed. The hearing subjects showed the largest asymmetry when short, easy words were begin processed. Their reaction times to abstract pictures and high imagery words were not strongly lateralized. The findings for the deaf were more in line with the second hypothesis. Three of the four stimulus modes were processed more efficiently in the LVF.

The third prediction, that deaf subjects would process all stimuli faster than hearing children was confirmed.

Discussion

The cerebral hemispheres of hearing and deaf children seem to be organized differently for the processing of tachtistiscopically presented words and pictures. The most striking difference is the speed of response in the two groups of subjects. The deaf subjects responded significantly faster to the task and had fewer errors than the hearing subjects (6.67% errors for the deaf subjects versus 8.75% for the hearing subjects). These error rates indicate that the longer processing time of the hearing children was not related to precision. The differential speed of response fits with the notion that deaf children tend to react to all visually presented stimuli in a similar manner, regardless of content; while hearing children don't. This explanation is buttressed by the significant interaction between the hemifields and the different stimuli. There is, however, at least one other explanation. The two year advantage that the deaf subjects had could have accounted for the faster reation times. To check this possibility, the reaction times for eight of the 8 and 9 year old deaf subjects were calculated. Their times did not differ from the larger group of deaf subjects ($\bar{X}$ = 1141 msec for LVF and 1123 msec for RVF). Hence age alone does not seem to account for the differences in reation times. The longer reaction

times of the hearing subjects could mean that these children are trying to use both verbal and spatial codes and hence are taking more time to process the stimulus information.

As predicted, the deaf childrenshowed an overall LVF advantage when processing the type of verbal and nonverbal stimuli used in this research. In contrast, the hearing subjects demonstrated an overall RVF lateralization for words. This result is consistent with other hemispheric research dealing with hearing populations (see Witelson, 1977). The hearing children did not, however, show a LVF superiority for pictures. In fact, the direction of the difference favored the RVF.

These results taken in conjunction with other studies comparing the performance of the deaf and hearing (McKeever et al. 1976; Manning et al., 1977; Phippard, 1977; Scholes & Fischler, 1979) support the view that there are significant differences in the way deaf and hearing individuals respond to a variety of visual stimuli presented to the two cerebral hemispheres. This global conclusion does not mean that audition is solely responsible for the specialization of the left hemisphere. As Poizner, Battison, and Lane (1979) show, the differences between deaf and hearing subjects are often ones of degree. In some studies the deaf exhibit a left preference for processing words that fails to reach significance. In others, the focus is on the fact that hearing subjects demonstrate significantly greater left hemispheric specialization for words than the deaf. These results suggest that audition may play a role in the development of left hemispheric specialization for words, but it is not critical to the development of some left hemispheric preference.

The present study attempted to extend these findings to younger deaf children. The results fit with the notion that the deaf have an early right

hemispheric preference for most visually processed stimuli. The conjunctions and articles that did not fit this pattern are, for the most part, abstract and difficult to represent visually. These data, if replicated, are congruent with the hypothesis that the lack of auditory cues has an early impact on hemispheric specialization.

Another explanation for the results of the present study is simply that auditory cues are an easy and abundant source of material for hearing children to analyze and sequence. The lack of this source of information would mean that the deaf must find other stimuli to sequence and analyses. If this is the case, then the right hemispheric preference that the deaf showed in the present study may simply be a lag in the development of left hemispheric specialization. These hypotheses should provide direction for future studies that investigate hemispheric specialization in younger deaf children. Longitudinal studies tracing the hemispheric specialization of deaf children from preschool to puberty would be particularly valuable.

The results of the present study support the hypothesis that young deaf children rely heavily on the right hemisphere. But there are several cautions that should be mentioned. The current study used reaction time as a dependent variable since this eliminated the need for deaf subjects to translate from words to signs. It is possible that other factors are influencing the deaf students' fast reaction times (see Swanson, Ledlow & Kinsbourne, 1978, for a discussion of reaction time). Another caution comes from the lack of matching in most of the studies that have compared deaf and hearing subjects. This failure to match groups of subjects on relevant variables limits the conclusions that can be drawn. However, matching is often difficult and can even be inappropriate. The IQ measures available on the deaf and hearing are usually not comparable. If subjects are matched on age, there is a big

disparity in reading skills. This problem is magnified if one uses subjects whose reading skills are marginal. Investigators can control handedness, age of onset of deafness, and whether or not other handicapping conditions exist. These seem to be the minimal requirements since they are so important in assessing hemispheric specialization for language. Despite the fact that matching between deaf and hearing subjects is a problem, the use of hearing control subjects is necessary to provide a baseline of normal functioning. The kinds of task variables that influence different experiments can not, at this stage of our knowledge, be predicted accurately. Hence control subjects allow an assessment of the effectiveness of the task manipulations.

Given these cautions, what kinds of conclusions can be drawn from the present study? The deaf and hearing subjects processed the visually presented information in a different manner. The deaf children favored the right hemisphere and responded significantly quicker than the hearing subjects. These results support the view that an auditory loss has an impact on the developing specialization of the brain. The extent of this impact and the long term course of hemispheric specialization in the deaf are questions for future research. Ultimately such research should provide valuable clues to the processes that are important in the developing specialization of the brain.

References

Bakker, D. 1979. Longitudinal development of dichotic ear asymmetry. Paper presented at Second INS European Conference, Noordwijkerhoot, Holland, June 27-30.

Bryden, M. P., & Allard, F. 1976. Visual hemifield differences depend on typeface. Brain and Language, 3, 191-200.

Bradshaw, J. L., Gates, A., & Patterson, K. 1976. Hemispheric differences in processing visual patterns. Quarterly Journal of Experimental Psychology, 28, 667-682.

Geschwind, N., & Levitsky, W. 1968. Human brain: left-right asymmetries in temporal speech region. Science, 161, 186-187.

Hiscock, M., & Kinsbourne, M. 1977. Selective listening asymmetry in pre-school children. Developmental Psychology, 13, 217-224.

Kimura, D. 1976. Zhe neural basis of language qua gesture. In H. Whitaker and H. Whitaker (Eds.) Studies in neurolinguistics, Volume 2, New York: Academic Press, Pp. 145-156.

Kimura, D., Battison, R., & Lubert, B. 1976. Impairment of nonlinguistic hand movements in a deaf aphasic. Brain and Language, 3, 566-571.

Kinsbourne, M., & Hiscock. 1977. Does cerebral dominance develop? In S. J. Segalowitz and F. A. Gruber (Eds.) Language Development and Neurological Theory. New York: Academic Press, 1977.

Liberman, A. M. 1974b. Language processing: state-of-the-art report. In R. E. Stark (Ed.), Sensory capabilities of hearing-impaired children. Baltimore: University Park Press, Pp. 129-141.

McKeever, W. F., Hoemann, H. W., Florian, V. A., & VanDeventer, A. D. 1976. Evidence of minimal cerebral asymmetries in the congenitally deaf. Neuropsychologia, 14, 413-423.

Manning, A. A., Gobel, W., Markman, R., & LaBrech, T. 1977. Lateral cerebral differences in the deaf in response to linguistic and nonlinguistic stimuli. Brain and Language, 4, 309-321.

Paivio, A., Yuille, J. C., & Madigan, S. A. 1968. Concreteness, imagery, and meaningfulness values for 925 nouns. Journal of Experimental Psychology: Monograph Supplement, 76, 1-25.

Phippard, D. 1977. Hemifield differences in visual perception in deaf and hearing subjects. Neuropsychologia, 15, 555-561.

Poizner, H., Battison, R., & Lane, H. 1979. Cerebral asymmetry for American Sign Language: The effects of moving stimuli. Brain and Language, 7, 351-362.

Sarno, J. E., Swisher, L. P., & Sarno, M. T. 1969. Aphasia in a congenitally deaf man. Cortex, 5, 398-414.

Scholes, R. J., & Fishler, I. 1979. Hemispheric function and linguistic skill in the deaf. Brain and Language, 7, 336-350.

Swanson, J., Ledlow, A., & Kinsbourne, M. 1978. Lateral asymmetries revealed by simple reaction time. In M. Kinsbourne (Ed.) Asymmetrical Function of the Brain. New York: Cambridge University Press.

Tomlinson-Keasey, C. T., & Kelly, R. R. 1979. A task analysis of hemispheric functioning. Neuropsychologia, 17, [illegible].

Witelson, S. F. 1977. Early hemisphere specialization and inter-hemispheric plasticity: An empirical and theoretical review. In S. J. Segalowitz and F. A. Gruber (Eds.) Language Development and Neurological Theory. New York: Academic Press.

Witelson, S. F., & Pallie, W. 1973. Left hemisphere specialization for language in the newborn (neuroanatomical evidence of asymmetry). Brain, 96, 641-646.

Acknowledgement

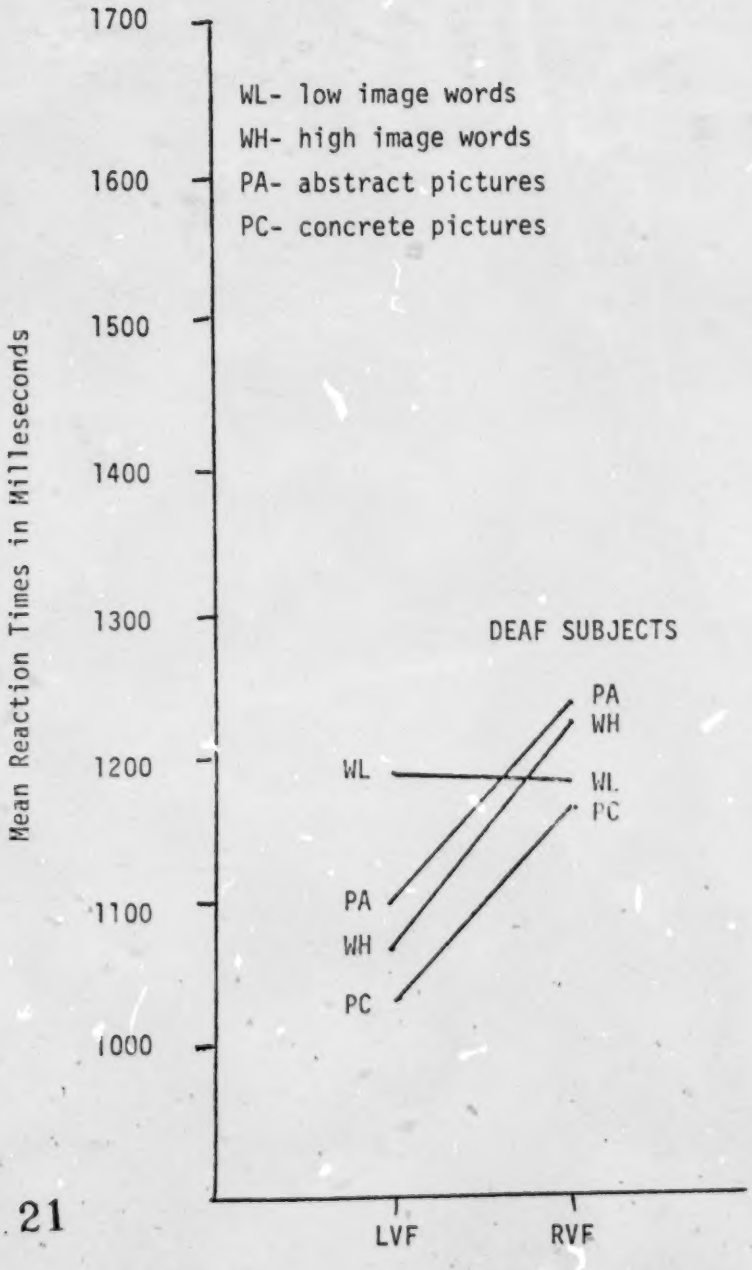
This research was supported by the Research Council at the University of Nebraska-Lincoln, with funds made available through N.I.H. Biomedical Services Support Grant 5 S05 RR07055-10. Part of the data are from the first author's doctoral dissertation conducted at the University of Nebraska-Lincoln.

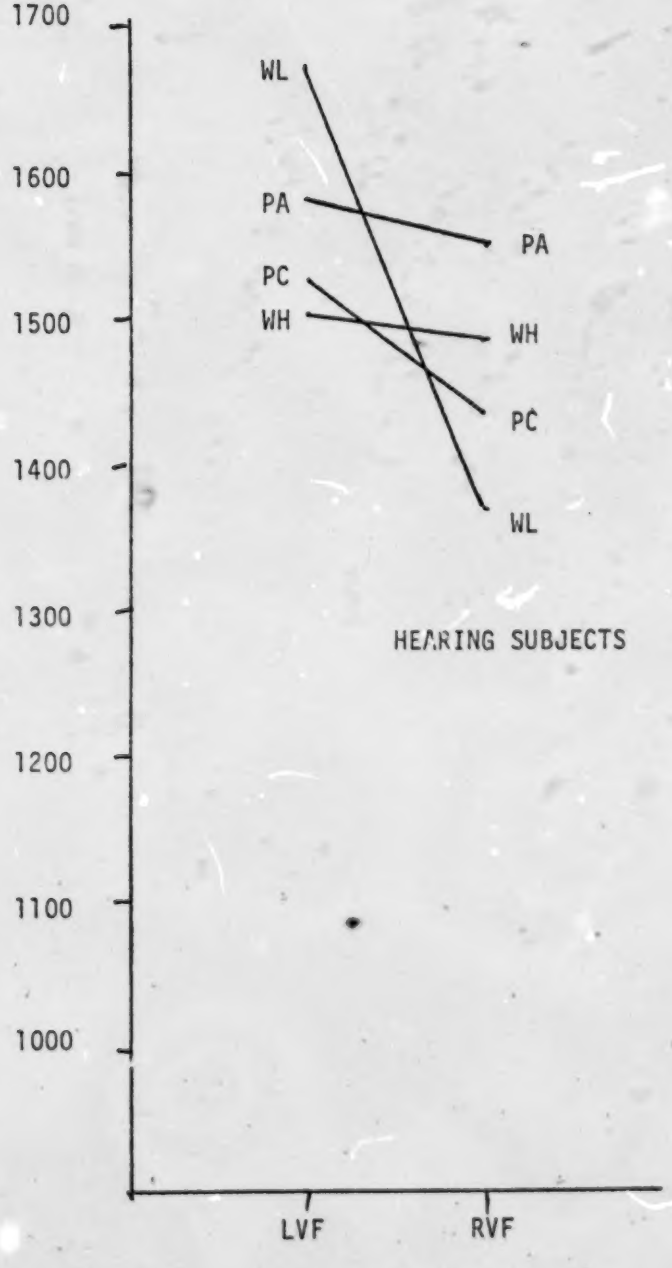
Requests for reprints should be sent to C. Tomlinson-Keasey, Psychology Department, University of California-Riverside, Riverside, CA 92521.

TABLE 1

MEAN REACTION TIMES (MS) AND STANDARD DEVIATIONS (IN PARENTHESES) FOR MODES, VISUAL FIELDS (LVF & RVF) AND MATCHED/UNMATCHED STIMULI

	DEAF SUBJECTS (N=30)		HEARING SUBJECTS (N=30)	
MODES	LVF	RVF	LVF	RVF
WORDS HIGH IMAGE				
Matched	1064 (243)	1177 (411)	1493 (705)	1408 (733)
Unmatched	1092 (347)	1267 (433)	1522 (625)	1581 (582)
WORDS LOW IMAGE				
Matched	1059 (307)	1216 (444)	1659 (591)	1420 (516)
Unmatched	1323 (653)	1152 (364)	1682 (619)	1329 (478)
PICTURES-CONCRETE				
Matched	1016 (369)	1171 (397)	1522 (484)	1436 (439)
Unmatched	1049 (305)	1172 (400)	1525 (563)	1446 (540)
PICTURES-ABSTRACT				
Matched	1040 (319)	1178 (388)	1580 (472)	1562 (555)
Unmatched	1157 (481)	1299 (629)	1592 (614)	1543 (484)
Overall mean	1100	1204	1572	1466


Mean Reaction Times in Milleseconds
1700
1600
1500
1400
1300
1200
1100
1000
WL- low image words
WH- high image words
PA- abstract pictures
PC- concrete pictures
DEAF SUBJECTS
WL
PA
WH
PC
WL
PA
WH
PC
LVF
RVF


1700
1600
1500
1400
1300
1200
1100
1000
WL
PA
PC
WH
PA
WH
PC
WL
HEARING SUBJECTS
LVF
RVF